Inter (Part-II) 2021

Physics	Group-I	PAPER: II
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

(i) If point charge q of mass m is released in a non-uniform electric field with field lines pointing in the same direction, will it make a rectilinear motion?

Ans A non-uniform field of a positive point charge has been shown in the following figure. If a small positive charge is placed at any point in the field, it will follow straight or rectilinear path along the field line due to repulsive force.

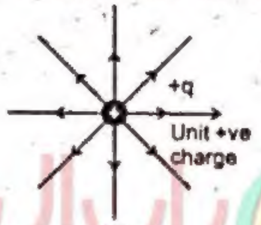


Fig.

(ii) Do electrons tend to go to region of high potential or of low potential?

Ans Since, electrons are negatively charged, so they tend to go to region of high potential, towards positive charge.

(iii) Electric field lines provide information about the strength of the electric field. Describe electric field intensity in terms of field lines.

Ans The electric field lines "map" provides information about the strength of the electric field. Field lines are closer to each other near the charges where the field is strong while they continuously spread out indicating a continuous decrease in the field strength.

"The number of lines per unit area passing perpendicularly through an area is proportional to the magnitude of the electric field."

The properties of electric field lines are as follows:

1. Electric field lines originate from positive charges and end on negative charges.
2. The tangent to a field line at any point gives the direction of the electric field at that point.
3. The lines are closer where the field is strong and the lines are farther apart where the field is weak.
4. No two lines cross each other. This is because E has only one direction at any given point. If the lines cross, E could have more than one direction.

(iv) Define and write relation for dielectric constant in terms of capacitances of a capacitor.

Ans If an insulating material, called dielectric, of relative permittivity ε_r is introduced between the plates, the capacitance of capacitor is enhanced by the factor ε_r. Capacitors commonly have some dielectric medium, thereby ε_r is also called as dielectric constant.

When a dielectric material is inserted between the plates, reading drops indicating a decrease in the potential difference between the plates. From the definition, $C = Q / V$, since V decreases while Q remains constant, the value of C increases. Then, $C_{med} = \frac{A\varepsilon_o\varepsilon_r}{d}$.

(v) Explain the principle of extension of right hand rule.

Ans In order to find the direction of force, consider the lines of force. The two fields tend to reinforce each other on left hand side of the conductor and cancel each other on the right side of it. The conductor tends to move towards the weaker part of the field *i.e.*, the force on the conductor will be directed towards right in a direction at right angles to both the conductor and the magnetic field. This rule is often referred as extension of right hand rule.

(vi) How does the graph pattern appear stationary on the screen of CRO? Explain the condition.

Ans The pattern will appear stationary only if the time T is equal to or is some multiple of the time of one cycle of

the voltage on y plates. It is thus necessary to synchronize the frequency of the time base generator with the frequency of the voltage at the y plates. This is possible by adjusting the synchronization controls provided on the front panel of the CRO.

(vii) Two charged particles are projected into a region where there is a magnetic field perpendicular to their velocities. If the charges are deflected in opposite directions, what can you say about them?

Ans The charged particles that are projected across the magnetic field perpendicular to their velocities, are:

$$\vec{F}_m = q\,(\vec{V} \times \vec{B})$$

This magnetic force on charged particles tends to deflect the particle into a curved path. If the charged particles are deflected opposite to each other, then the particles are oppositely charged, *i.e.,* one particle may be positively charged and the other one may be negatively charged.

(viii) If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero?

Ans No, we cannot say that the magnetic field in that region is zero, because a charged particle can move in a straight line through some region of magnetic field if the direction of motion of the charged particle is parallel to the direction of the magnetic field.

(ix) What is the importance of minus sign in the expression $\left(\varepsilon = -N\dfrac{\Delta\phi}{\Delta t}\right)$ for Faraday's law of electromagnetic induction?

Ans Faraday's law of electromagnetic induction states that:

"The average emf induced in a conducting coil of N loops is equal to the negative of the rate at which the magnetic flux through the coil is changing with time."

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

The minus sign indicates that the direction of the induced emf is such that it opposes the change in flux.

(x) Why self-induced emf is also called as back emf?

Ans "The emf that causes an induced emf in the coil when magnetic flux through the coil changes, is called self-induced emf." The self-induced emf must oppose the change that produced it. That is why, the self-induced emf is sometimes called as back emf. This is exactly in accord with the Lenz's law. If the current is increased, the induced emf will be opposite to that of battery and if the current is decreased the induced emf will aid, rather than opposing the battery.

(xi) Does the induced emf always act to decrease the magnetic flux through a circuit?

Ans No, the induced emf always opposes the cause that produces it. If the magnetic flux through the circuit is increasing, then the induced emf acts to decrease the magnetic flux. If magnetic flux is decreasing, then the induced emf acts to increase the value of magnetic flux. Hence, the induced emf does not always act to decrease the magnetic flux through the circuit.

(xii) Is it possible to change both the area of the loop and the magnetic field passing through the loop and still not have an induced emf in the loop?

Ans Yes, it is possible. When area increases, the magnetic field decreases and when magnetic field increases, area decreases, but the magnetic flux passing through the loop does not change. In this situation, no emf is induced in the loop.

i.e., $\phi = \Delta B \,.\, A = \text{constant}$

$\Rightarrow \quad \Delta\phi = 0$

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t} = 0.$$

3. Write short answers to any EIGHT (8) questions: (16)

(i) What is Wheatstone bridge? How can it be used to determine an unknown resistance?

Ans The Wheatstone bridge consists of four resistances R_1, R_2, R_3 and R_4 connected in such a way so as to form a mesh ABCDA. A battery is connected between points A and C. A sensitive galvanometer of resistance R_g is connected between points B and D. If the switch S is closed, a current will flow through the galvanometer. We are to determine the condition under which no current flows through the galvanometer even after the switch is closed.

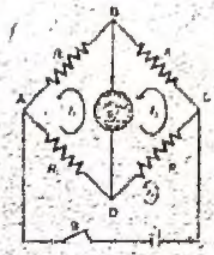


Fig. Wheatstone bridge circuit.

If we connect three resistances R_1, R_2 and R_3 of known adjustable values and a fourth resistance R_4 of unknown value and the resistances R_1, R_2 and R_3 are so adjusted that the galvanometer shows no deflection, then from the known resistances R_1, R_2 and R_3 the unknown resistance R_4 can be determined by using equation. *i.e.*,

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

(ii) Differentiate between resistance and resistivity.

Ans Differences between resistance and resistivity:

Resistance	Resistivity
1. Resistance is the characteristic of a particular wire.	1. Resistivity is the property of the material of which the wire is made.
2. Resistance is a measure of the opposition to the motion of electrons due	2. Resistivity is the tendency of material to oppose the flow of

to their continuous bumping with the atoms of the lattice.	current.
3. The unit of resistance is ohm (Ω).	3. The unit of resistivity is ohm-meter (Ωm).

(iii) Explain, why the terminal potential difference of a battery decreases when the current drawn from it is increased?

Ans As we already know a relation for terminal potential difference of a battery, that is

$$IR = E - Ir$$

Or $V_t = E - Ir$ ... (1) $\because$ $(IR = V_t)$

Here F = emf of battery

r = internal resistance of battery

$\therefore$ Ir = P.D. across internal resistance

Equation (1) shows that when I is increased, the factor I r becomes large and V'_t becomes small. Thus, terminal potential difference of a battery decreases when the current drawn from it is increased.

(iv) How does doubling the frequency affect the reactance of: (a) An inductor (b) A capacitor

Ans (a) The reactance of inductor is given by

$$X_L = 2\pi fL \qquad \Rightarrow \quad X_L \propto f$$

This result shows that if the frequency of A.C is doubled, then the reactance of an inductor also becomes doubled.

(b) The formula for the reactance of capacitor is given by

$$X_c = \frac{1}{2\pi fC}$$

If we double the frequency, then capacitance reactance X'_c becomes as

$$X'_c = \frac{1}{2\pi(2f)C} = \frac{1}{2(2\pi fC)}$$

or $X'_c = \frac{1}{2}(X_c)$.

(v) **A sinusoidal current has rms value of 10 A. What is the maximum or peak value?**

Ans rms (effective) values of current = I_{rms} = 10 A

Peak values = Maximum value = I_o = ?

Using the formula,

$$I_{rms} = \frac{I_o}{\sqrt{2}}$$

or $$I_o = \sqrt{2} \cdot I_{rms}$$

$$= 1.414 \times 10 \qquad (\because \sqrt{2} = 1.414)$$

$$I_o = 14.14 \text{ A}$$

Thus, maximum or peak value of current is 14.14 A.

(vi) **Explain the power dissipation in an inductor.**

Ans It can be seen that no power is dissipated in a pure inductor. In the first quarter of cycle, both V and I are positive so the power is positive, which means energy is supplied to inductor. In the second quarter, V is positive but I is negative. Now power is negative which implies that energy is returned by the inductor. Again in third quarter, it receives energy but returns the same amount in the fourth quarter. Thus, there is no net change of energy in a complete cycle. Since an inductor coil does not consume energy, the coil is often employed for controlling A.C. without consumption of energy.

(vii) **What is meant by para, dia and ferromagnetic substances? Give examples of each.**

Ans The orbits and the spin axes of the electrons in an atom are so oriented that their fields support each other and the atom behaves like a tiny magnet. Substances with such atoms are called **paramagnetic substances.**

In second type of atoms, there is no resultant field as the magnetic fields produced by both orbital and spin motions of the electrons might add up to zero. These are called **diamagnetic substances**. For example, the atoms of water, copper, bismuth and antimony.

However, there are some solid substances *e.g.*, Fe, Co, Ni, Chromium dioxide, and Alnico (an iron aluminium-nickel-cobalt alloy) in which the atoms co-operate with each other in such a way so as to exhibit a strong magnetic effect. They are called **ferromagnetic substances**. Ferromagnetic materials are of great interest for electrical engineers.

(viii) What is meant by hysteresis loss? How is it used in the construction of a transformer?

Ans Hysteresis loss is the energy expended to magnetize and demagnetize the core material in each cycle of the A.C.

In order to improve the efficiency, care should be exercised to minimize all the power losses. For example, core should be assembled from the laminated sheets of a material whose hysteresis loop area is very small. The insulation between lamination sheets should be perfect so as to stop the flow of eddy currents. The resistance of the primary and secondary coils should be kept to a minimum.

(ix) Differentiate between Young modulus Y and bulk modulus K.

Ans Differences between Young modulus Y and Bulk modulus K:

Young modulus Y	Bulk modulus K
1. In case of linear deformation, the ratio of tensile (or compressive) stress ($\sigma = F/A$) to tensile strain $\varepsilon = \Delta l / l$ is called Young's modulus.	1. For three-dimensional deformation, when volume is involved, then the ratio of applied stress to volumetric strain is called Bulk modulus.
2. $Y = \dfrac{F/A}{\Delta l / l}$	2. $K = \dfrac{F/A}{\Delta V / V}$

(x) Why charge carriers are not present in the depletion region?

Ans The n-region contains free electrons as majority charge carriers and p-region contains holes as majority

charge carriers, just after the formation of the junction. The free electrons in the n-region because of their random motion, diffuse into the p-region. As a result of their diffusion, a chargeless region is formed around the junction in which the charge carriers are not present.

(xi) What is the principle of virtual ground? Apply it to find the gain of an inverting amplifier.

Ans Since, the open loop gain of operational amplifier is very high of the order of 10^5.

$$A_{OL} = \frac{V_o}{V_+ - V_-} = 10^5.$$

This is possible only when $V_+ - V_-$ is very small *i.e.,* $V+ - V- \approx 0 \Rightarrow V+ \approx V-$, *i.e.,* both inputs of op-amp are virtually at same potential. Thus, if one input is grounded, the other is virtual grounded *i.e.,* if $V_+ = 0 \Rightarrow V_- = 0$. This is known as principle of virtual ground.

Current through, $R_1 = I_1 = \dfrac{V_{in} - V_-}{R_1} = \dfrac{V_{in} - 0}{R_1} = \dfrac{V_{in}}{R_1}$

Current through, $R_2 = I_2 = \dfrac{V_- - V_o}{R_2} = \dfrac{0 - V_o}{R_2} = -\dfrac{V_o}{R_2}$

As practically no current flows between (–) and (+) terminals, so according to Kirchhoff's current rule,

$$I_1 = I_2$$

or $\dfrac{V_{in}}{R_1} = -\dfrac{V_o}{R_2} = \dfrac{V_{in}}{R_1}$ or $\dfrac{V_o}{V_{in}} = -\dfrac{R_2}{R_1}$

As V_o / V_{in} is defined as gain G of the inverting amplifier, so

$$G = -\frac{R_2}{R_1}.$$

(xii) What is the potential barrier of silicon and germanium?

Ans Just after the formation of the p-n junction, The free electrons in the n-region, because of their random motion, diffuse into the p-region. As a result of this diffusion, a

region is formed around the junction in which charge carriers are not present. This region is known as depletion region.

There are positive and negative ions which constitute the depletion region. Due to charge on these ions, a potential difference develops across the depletion region. Its value is 0.7 V in case of silicon and 0.3 V in case of germanium. This potential difference, called potential barrier, stops further diffusion of electrons into the p-region.

4. Write short answers to any SIX (6) questions: (12)

(i) As a solid is heated and begins to glow, why does it first appear red?

Ans When a solid is heated, then at the start of its glow, it appears red because it emits wavelength of red light radiation.

(ii) Why don't we observe Compton effect with visible light?

Ans The photons of visible light have smaller energy and momentum than the photons of X-rays. Also their penetrating power is almost negligible. So, photons of visible light are unable to show Compton's effect.

(iii) What advantages an electron microscope has over an optical microscope?

Ans The resolving power of an electronic microscope is thousand times greater than that of an optical microscope. Therefore, such minor details which cannot be seen by an optical microscope can be observed by an electronic microscope.

(iv) What are the advantages of laser over ordinary light?

Ans The laser light is intense and coherent, so it does not spread while passing through a medium, its energy can be focused at a point to get enough energy for welding, cutting and surgical tool which ordinary light cannot do.

(v) What is Helium-Neon Laser?

Ans It is a most common type of lasers used in physics laboratories. Its discharge tube is filled with 85% heli[illegible] and 15% neon gas. The neon is the lasing or acti[illegible] medium in this tube. By chance, helium and neon h[illegible]

nearly identical metastable states, respectively, located 20.61 eV and 20.66 eV level. The high voltage electric discharge excites the electrons in some of the helium atoms to the 20.61 eV state. In this laser, population inversion in neon is achieved by direct collisions with same energy electrons of helium atoms.

(vi) Why are heavy nuclei unstable?

Ans The heavy nuclei have very small value of their binding energy per nucleon. So, they are unstable, and less energy is required to split heavy nuclei.

(vii) What factors make a fusion reaction difficult to achieve?

Ans This reaction requires large amount of energy and temperature up to million degree centigrade. These requirements are not possible to achieve, so the fusion reaction is very difficult to achieve.

(viii) Define mass defect and binding energy.

Ans **Mass defect:**

The mass of the nucleus is always less than the total mass of all the protons and neutrons making up the nucleus. In the nucleus, the missing mass is called the mass defect Δm given by,

$$\Delta m = Zm_p + (A - Z)\, m_n - m_{nucleus}$$

As Z is the total number of protons in the nucleus and m_p is the mass of a proton, then Zm_p is the total mass of all the protons. $(A - Z)$ is the total number of neutrons and as m_n is the mass of a single neutron, $(A - Z)\, m_n$ is the total mass of all the neutrons. The term $m_{nucleus}$ is the experimentally measured mass of the entire nucleus.

Binding energy:

The missing mass is converted to energy in the formation of the nucleus. This energy is found from Einstein's mass energy relation

$$E = (\Delta m)\, c^2$$

and is called the binding energy (B.E.) of the nucleus. The binding energy of a nucleus is

$$B.E = (\Delta m)\, c^2 = Zm_p c^2 + (A - Z)\, m_n c^2 - m_{nucleus} c^2$$

(ix) **What are hadrons? Give examples.**

Ans Hadrons are particles that experience the strong nuclear force. In addition to protons, neutrons and mesons are hadrons. The particles equal in mass or greater than protons are called baryons and those lighter than protons are called mesons.

SECTION-II

NOTE: Attempt any THREE (3) questions.

Q.5.(a) State Gauss's law. Find out the electric intensity due to an infinite sheet of charge. (5)

Ans For Answer see Paper 2019 (Group-I), Q.5.(a).

(b) 0.75 A current flows through an iron wire when a battery of 1.5 V is connected across its ends. The length of the wire is 5 m and its cross-sectional area is 2.5×10^{-7} m^2. Compute the resistivity of iron. (3)

Ans The resistance R of the wire can be calculated by eq. 13.2, *i.e.*,

$$V = IR = R = \frac{V}{I}\,\frac{1.5\ V}{0.75\ A} = 2.0\ VA^{-1} = 2.0\ \Omega$$

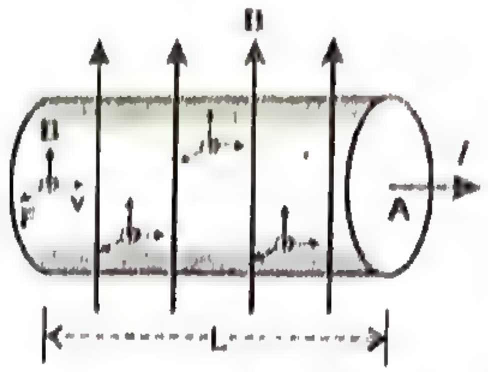
The resistivity ρ of iron of which the wire is made is given by

$$\rho = R\frac{A}{L} = \frac{2.0\ \Omega \times 2.5 \times 10^{-7}\ m^2}{5.0\ m} = 1.0 \times 10^{-7}\ \Omega\, m$$

Q.6.(a) Derive the expression for force on moving charge in a uniform magnetic field. (5)

Ans Consider the situation where we see a portion of the wire that is carrying a current I. Suppose there are *n* charge carriers per unit volume of the wire, and that each is moving with velocity v as shown in figure. We will now

find how long it takes for all the charge carriers originally in the wire segment shown to exit through the end area A.



The volume of the wire segment is AL. Because there are n charge carriers per unit volume, the number of charge carrier in the segment is n AL. If the charge on a charge carrier is q, each of it, as it crosses the end area, will transport a charge q through it. Assuming the speed of the carriers to be v, the carrier entering the left face of the segment takes a time $\Delta t = L/v$ to reach the right hand face. During this time, all the charge carriers originally in the segment, namely n AL, will exit through the right hand face. As each charge carrier has a charge q, the charge ΔQ that exits through the end area in time $\Delta t = L/v$ is

$$\Delta Q = n\,AL\,q$$

Then, from the definition of the current, the current I through the conductor is

$$I = \frac{\Delta Q}{\Delta t} = \frac{n\,A\,L\,q}{L/v}$$

$$= n\,Aqv \qquad (1)$$

The force on the segment L of a conductor, carrying current I is given by

$$F_L = I\,L \times B$$

Substituting the value of the current I,

$$F_L = n\,Aqv\,L \times B \qquad (2)$$

In figure, it can be see that the direction of the segment L is the same as the direction of the velocity of the charge carriers. If $\hat{L}$ is a unit vector along the direction

of the segment L and $\hat{v}$, a unit vector along the velocity vector v, then $\hat{L} = \hat{v}$

$$\because \quad v\,L = v\,\hat{L}\,L$$
$$= v\,\hat{v}\,L = v\,L$$

Substituting the value of v L in eq. (2), we have

$$F_L = n\,Aq\,(vL) \times B$$
$$= n\,ALq\,v \times B$$

n AL is the total number of charge carries in the segment L. so the force experienced by a single charge carrier is

$$F = \frac{F_L}{n\,AL} = q\,v \times B$$

Thus the force experienced by a single charge carrier moving with velocity v in magnetic field of strength B is,

$$F = q\,(v \times B) \qquad (3)$$

Although the eq. (3) has been derived with reference to charge carrier moving in a conductor but it does not involve any parameter of the conductor, so the eq. (3) is quite general and it holds for any charge carrier moving in a magnetic field.

If an electron is projected in a magnetic field with a velocity v, it will experience a force which is given by putting q = –e in eq. (3) where e is the charge on an electron.

$$F = -e\,v \times B \qquad (4)$$

In case of proton, F is obtained by putting q = +e.

$$F = +e\,v \times B \qquad (5)$$

(b) An alternating current generator operating at 50 Hz has a coil of 200 turns. The coil has an area of 120 cm². What should be the magnetic field in which the coil rotates in order to produce an emf of maximum value of 240 volts? (3)

Ans Frequency of rotation = f = 50 Hz

No. of turns of the coil = N = 200

Area of the coil = A = 120 cm² = 1.2×10^{-2} m²

Maximum emf = ε_{max} = 240 V

Magnetic flux density = B = ?

First, we shall find the angular speed ω.

Using $\omega = 2\pi f$

$$\omega = 2 \times \frac{22}{7} \times 50 = 314.3 \text{ rad s}^{-1}$$

Using $\varepsilon_o = N\omega AB$ or $B = \frac{\varepsilon_o}{N\omega A}$

$$B = \frac{240 \text{ V}}{200 \times 314.3 \text{ rad s}^{-1} \times 1.2 \times 10^{-2} \text{ m}^2}$$

$$B = 0.32 \text{ Vs rad}^{-1} \text{ m}^{-2} = 0.32 \text{ T}$$

Q.7.(a) How OP amplifier can be made as inverting amplifier? Explain your answer by circuit diagram. (5)

Ans OP-AMP as inverting Amplifier:

The figure shows the circuit of an op-amp when used as an inverting amplifier. The input signal V_{in} which is to be amplified, is applied at inverting terminal (–) through a resistance R_1. V_o is its output. The non-inverting terminal (+) is grounded, *i.e.*, its potential is zero. We know that A_{OL} is very high, of the order of 10^5. As V_o may have any value between $+V_{CC}$ (+12 V) and $-V_{CC}$ (–12 V). So for finite (± 12 V) value of V_o, $V_+ - V_- \approx 0$ or $V_+ \approx V_-$. Since V_+ is at ground so V_- is virtually at ground potential *i.e.*, $V_- \approx 0$. Referring to Fig.

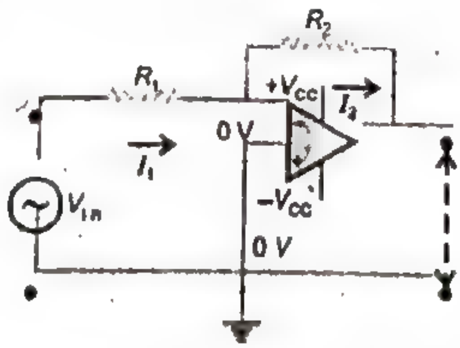


Fig.

Current through, $R_1 = I_1 = \frac{V_{in} - V_-}{R_1} = \frac{V_{in} - 0}{R_1} = \frac{V_{in}}{R_1}$

Current through, $R_2 = I_2 = \frac{V_- - V_o}{R_2} = \frac{0 - V_o}{R_2} = \frac{V_o}{R_2}$

As practically no current flows between (–) and (+) terminals, so according to Kirchhoff's current rule,

$$\text{or} \quad \frac{V_{in}}{R_1} = -\frac{V_o}{R_2} = \frac{V_{in}}{R_1} \quad \text{or} \quad \frac{V_o}{V_{in}} = -\frac{R_2}{R_1}$$

As V_o / V_{in} is defined as gain G of the inverting amplifier, so

$$G = -\frac{R_2}{R_1}$$

The negative sign indicates that the output signal is 180° out of phase with respect to input signal. It is interesting to note that the closed loop gain depends upon the two externally connected resistances R_1 and R_2. The gain is independent of the circuit inside the amplifier.

If $R_1 = 10\ k\Omega$ and $R_2 = 100\ k\Omega$, the gain of the amplifier is

$$G = \frac{V_o}{V_{in}} = \frac{-R_2}{R_1} = \frac{-100k\,\Omega}{10k\,\Omega} = -10$$

(b) Find the value of the current and inductive reactance when A.C. voltage of 220 V at 50 Hz is passed through an inductor of 10 H. (3)

Ans

AC voltage = V = 220 volts

Frequency = f = 50 Hz

Inductance = L = 10 H

Current = I = ?

Inductive Reactance = X_L = ?

By using the formula of reactance,

$$X_L = 2\pi f L$$

$$X_L = 2(3.14)(50)(10)$$

$$X_L = 3140\ \Omega$$

And the formula for current,

$$I = \frac{V}{X_L}$$

$$= \frac{220}{3140}$$

$$I = 0.07\ A$$

Q.8.(a) Explain the principle, construction and working of Geiger-Mullar Counter. (5)

Ans Geiger-Muller Counter:

Geiger-Muller tube is a well-known radiation detector. The discharge in the tube results from the ionization produced by the incident radiation. It consists of a stiff central wire acting as an anode in a hollow metal cylinder acting as a cathode filled with a suitable mixture of gas at about 0.1 atmospheric pressure. One end of the tube has a thin mica window to allow the entry of α or β-particles and other end is sealed by non-conducting material and carries the connecting pins for the two electrodes. A high potential difference, (about 400 V for neon-bromine filled tubes) but slightly less than that necessary to produce discharge through the gas is maintained between the electrodes. When radiation enters the tube, ionization is produced. The free electrons are attracted towards the positively charged central wire. As they are accelerated towards the wire by a strong electric field, they collide with other molecules of the gas and knock out more electrons which in turn do the same and produce a cascade of electrons that move towards the central wire. This makes a short pulse of electric current to pass through an external resistor. It is amplified and registered electronically. The counter, which also provides the power, is called a scaler.

The cascade of electrons produced by the entry of an ionizing particle is counted as a single pulse of

approximately the same size whatever the energy or path of the particle maybe. It cannot, thus, discriminate between the energies of the incident particle as output pulses are same. The entire electron pulse takes less than 1 μs. However, positive ions, being very massive than the electrons, take several hundred times as long to reach the outer cathode. During this time, called the dead time ($\sim 10^{-4}$ s) of the counter, further incoming particles cannot be counted. When positive ions strike the cathode, secondary electrons are emitted from the surface. These electrons would be accelerated to give further spurious counts. This is prevented by mixing a small amount of quenching gas with the principal gas.

The quenching gas must have an ionization potential lower than that of inert of principal gas. Thus, the ions of quenching gas reach the cathode before principal gas ions. When they reach near the cathode, they capture electrons and become neutral molecules. Following neutralization, the excess energy of the quenching molecules is dissipated in dissociation of the molecules rather than in the release of electrons from the cathode. For example, bromine gas is added to neon gas. The bromine molecules absorb energy from the ions or secondary electrons and dissociate into bromine atoms. The atoms then readily recombine into molecules again for the next pulse. The gas quenching is called self-quenching. Although all commercial Geiger tubes are self-quenched, it is common practice to use electronic quenching in addition. For this purpose, a large negative voltage is applied to the anode immediately after recording the output pulse. This reduces the electric field below the critical value for ionization by collision. The negative voltage remains until all the positive ions are collected at cathode thus preventing secondary pulses.

(b) A 1.25 cm diameter cylinder is subjected to a load of 2500 kg. Calculate the stress on the bar in mega pascals. (3)

Ans Given that:

Diameter of cylinder = d = 1.25 cm = 0.0125 m

Load = m = 2500 kg

To find:

Stress on the bar = σ = ?

By formula,

$$\boxed{\sigma = F/A}$$

$$F = mg$$

$$A = \text{Area} = \pi r^2$$

As, $r = \frac{d}{2}$

$$A = \pi \left(\frac{d}{2}\right)^2$$

$$A = 3.14 \left(\frac{0.0125}{2}\right)^2$$

$$A = 1.22 \times 10^{-4}\ m^2$$

So, $\sigma = \frac{mg}{A}$

$$\sigma = \frac{2500 \times 9.8}{1.22 \times 10^{-4}}$$

$$= 20081.9 \times 10^4$$

$$= 200 \times 10^6\ Pa$$

Stress: $\boxed{\sigma = 200\ M\ Pa}$

Q.9.(a) State postulates of Bohr's model of the hydrogen atom and then show that hydrogen atom have quantized radii? (5)

Ans For Answer see Paper 2019 (Group-II), Q.9.(a).

(b) An electron is accelerated through a potential difference of 50 V. Calculate its de Broglie wavelength. (3)

Ans

$m = 9.1 \times 10^{-31}$ kg, $V_o = 50$ V,

$\lambda = ?$, $e = 1.6 \times 10^{-19}$ C

$$\frac{1}{2} mv^2 = V_o e$$

$$p = mv = \sqrt{2\, mV_o e}$$

then $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2\, mV_o e}}$

$$= \frac{6.63 \times 10^{-34}\ \text{Js}}{\sqrt{2 \times 9.1 \times 10^{-31}\ \text{kg} \times 50\ \text{JC}^{-1} \times 1.6 \times 10^{-19}\ \text{C}}}$$

$\lambda = 1.74 \times 10^{-10}$ m